The Rôle of Wave Impact and Desiccation on the Distribution of *Littorina sitkana* Philippi, 1845

BY

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(1 Text figure)

INTRODUCTION

Two species of periwinkles, *Littorina scutulata* Gould, 1849, and *L. sitkana* Philippi, 1845, coexist on most beaches near the city of Vancouver, in the Gulf Islands and on the west coast of Vancouver Island, British Columbia. *Littorina sitkana*, unlike *L. scutulata,* is absent from dry beaches and from wave exposed sites lacking shelter, but thrives in wave-sheltered and damp habitats such as mud flats, tide pools and crevices (Behrens, 1971).

Littorina scutulata has a planktonic dispersal stage, whereas *L. sitkana* develops directly from benthic egg masses (Behrens, *op. cit.*). Thus, the maintenance of *L. scutulata* populations in any one place is dependent upon constant planktonic recruitment whereas the persistence of *L. sitkana* populations is dependent upon the survival of all developmental stages in the life cycle. Results from this study indicate that the physical factors such as desiccation acting on juveniles and wave impact affecting adults can select against *L. sitkana* and exclude this species from some beaches.

THE RÔLE of WAVE IMPACT on the DISTRIBUTION of *Littorina sitkana*

Extremely small *Littorina scutulata* are found on wave-swept and crevice-less beaches such as Chesterman's Island on the west coast of Vancouver Island. To investigate the action of intense surf as a possible factor acting selectively against *L. sitkana* as well as against large animals of both species, series of laboratory and field tests were performed.

METHODS

An equal number of animals of both species, or of a single species, but of two size classes, were painted with cellulose-base paint. When species comparisons were made, *Littorina scutulata* and *L. sitkana* were matched for size. The animals were then dipped in sea water and allowed to attach to the rock or barnacle substratum of the beach and were then subjected to wave action of the incoming tide. After a trial period ranging from 6 hours to 2 days, the test site and adjacent areas were carefully searched. All missing animals were assumed to have been dislodged by waves. Laboratory experiments using concrete slabs as substrata and a running sea water jet to simulate wave force were performed to check field results.

RESULTS and DISCUSSION

Both field and laboratory data indicate that *Littorina scutulata* are less likely to be dislodged by waves than are *L. sitkana* (Table 1). *Littorina sitkana,* with its round shape and many grooves, may offer more resistance to wave action than the more streamlined *L. scutulata.*

Large *Littorina sitkana* were more easily dislodged by wave impact than smaller ones (Table 1). Large *L. scutulata* appeared as resistant to wave force as smaller ones (Table 1). Thus, young (or small) *L. sitkana* could presumably live on exposed beaches; however, wave action would select against them as they attained reproductive size (ca. 5 mm).

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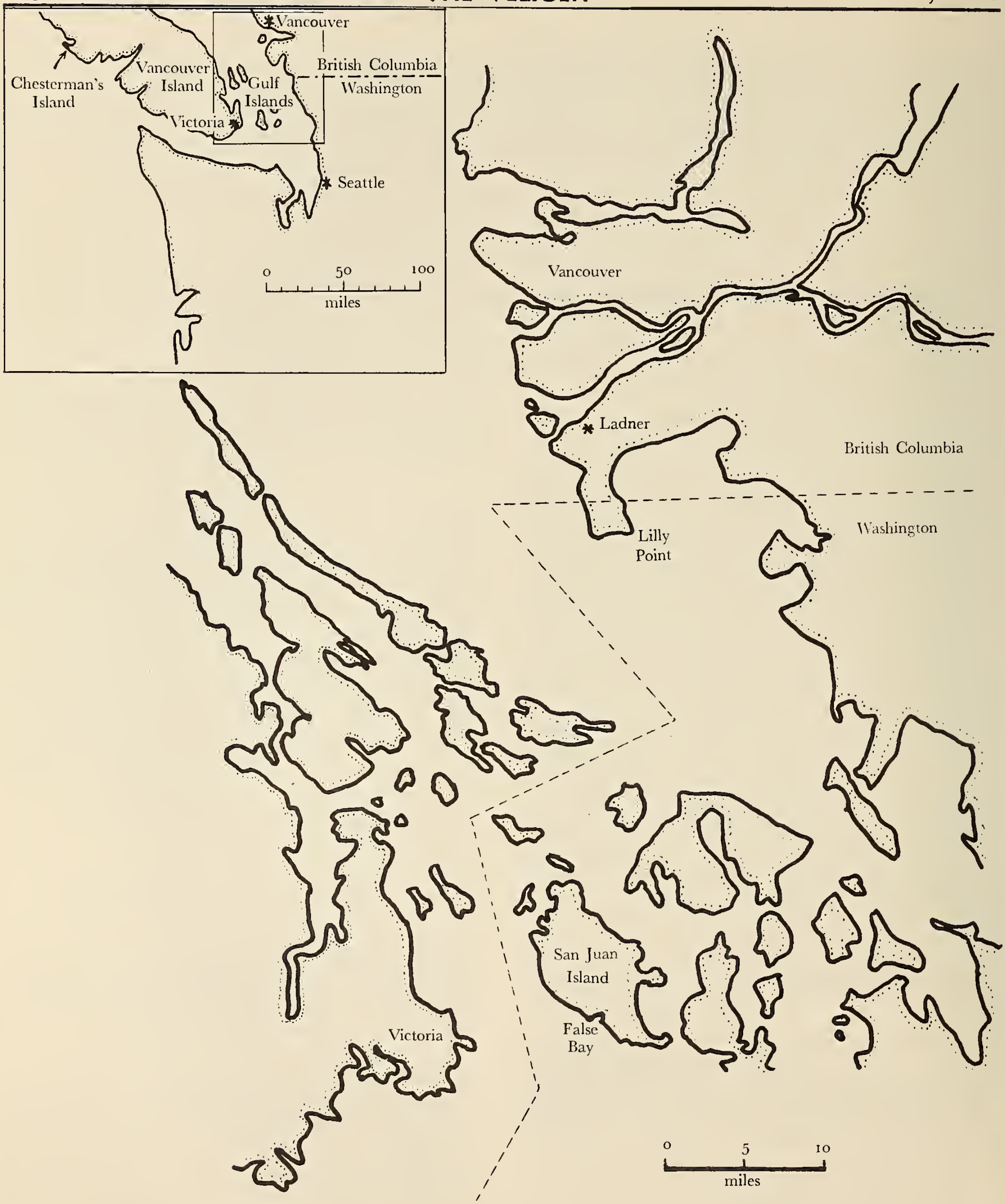

Figure 1

Map of Puget Sound and Vicinity showing locations of study areas

Table 1

Ability of *Littorina sitkana* and *Littorina scutulata* to resist wave exposure in the field and in the laboratory

Source of data	Proportions of animals remaining on substrate after test interval		Difference between comparisons Chi squared	
	L. sitkana	*L. scutulata*		
Field pooled data from 8 runs	254/487	366/487	55.657	***
Laboratory pooled data from 3 runs	3/54	19/54	12.842 (Y)	***
	small *L. scutulata*	large *L. scutulata*		
Field	35/50	34/50	N. S.	
	small *L. sitkana*	large *L. sitkana*		
Field	34/50	19/50	9.0325	**
Laboratory pooled data from 6 runs	37/121	15/126	12.947	***

(Y) – Yates correction for small cell frequencies was used numbers of * indicate level of significance when the null hypothesis of no difference between values has been rejected. * = α 0.05; ** = α 0.01; *** = α 0.001; n. s. indicates no significant difference

DESICCATION of JUVENILE STAGES as a POSSIBLE FACTOR RESTRICTING the DISTRIBUTION of *Littorina sitkana*

Survival of juvenile *Littorina sitkana* in a location inhabited naturally by *L. scutulata* only was investigated at Lilly Point (Figure 1). The rocky foreshore in this area is characterised by barnacle-covered cobble and rocks, not larger than 15 cm in diameter, resting on a sandy bottom. The low intertidal area is mostly sand interspersed with 4 barnacle covered concrete blocks (50 × 50 × 50 cm). I worked on the site of an abandoned fish cannery where an artificial substratum, consisting of compressed tin can scraps and cobble, is completely covered with barnacles and extends from the mid to the high intertidal region. Numerous barnacle-covered pilings (the remains of the cannery's pier) run in rows from the mid to high intertidal area. Absence of shade, as well as good drainage, tend to make the Lilly Point site a dry beach at low tides in sunny weather. Animals cannot find shelter under the cobble and rocks, for these are embedded in coarse sand.

To determine the critical factor in the life history which could prevent *Littorina sitkana* from living at Lilly Point, adults, egg masses and newly hatched snails were transplanted to the area.

MATERIALS and METHODS

To determine whether adult *Littorina sitkana* could live at Lilly Point, 500 young *L. sitkana* (not more than 5 mm in length) were released on the "compressed tin can rock" and on one piling stump in May of 1969.

Eight "cages" were prepared by pulling a square of fine plankton netting over the concave half of little neck clam shells. Four of the cages contained 10 newly hatched snails each and 4 cages contained 5 older snails (1 mm or longer). One of each type of cage was set up in the following locations: on pilings at the 13 foot tidal level, in artificial tide pools (32 ounce orange juice jars) at the 13 foot tidal level, on pilings at the 9 foot level, and in artificial tide pools at the 9 foot tidal level. The "tide pools" and cages were attached to the piling stumps using rubber bands cut from an inner tube. The number of surviving animals, salinity, and temperature of the tide pools and air were recorded the next day (Table 2).

Egg masses collected from False Bay, San Juan Island (Figure 1) were divided into two parts. Each half was

Table 2

Survival of two size classes of juvenile *Littorina sitkana* caged at the 9 foot and 13 foot tidal levels at Lilly Point from May 17 to May 18, 1969

Position of cages	Salinity of pools	Temperature	Recovery of *Littorina sitkana*
medium tidal level (9 ft) pool	30‰	27° C water	7 small (newly hatched) snails all with their foot moving. Cage with larger (1.0 mm or longer) snails was lost
medium tidal level (9 ft) dry		20° C air	9 small snails, all alive, 5 large snails, all but one opened operculum when moistened
high tidal level (13 ft) pool	25‰	27° C water	8 small snails, all alive; 5 large snails, all alive
high tidal level (13 ft) dry		20° C air	9 small snails, all dead; 4 large snails, 3 alive, 1 with broken shell

placed into a plastic petri dish lid and fine plankton netting was wrapped around the dishes. These "cages" were attached to the pilings at the high tide levels and to concrete blocks at the low tide levels, so that half of each egg mass was represented at each tidal level. The number of hours of exposure to direct mid-day sunshine at the 5 and 12 foot tide level was estimated from weather data (for Ladner, British Columbia, compiled by Mrs. M. A. Behrens) and a tide table. The condition of the egg masses and the number of hatched snails were recorded subsequently (Table 3).

Table 3

Hatching success of *Littorina sitkana* egg masses at Lilly Point

Five egg masses of *Littorina sitkana* were divided in two. One half of each egg mass was attached to pilings at the high tide level and the other half to concrete blocks at the low tide level at Lilly Point

Initial color of egg mass	Tidal height of cage	Number of hatched *Littorina sitkana* September 1	September 7
pink	5 ft	not sampled	50 alive *
	11 ft	red egg mass	0 alive
light pink	5 ft	not sampled	7 alive *
	13 ft	yellow and dry	0 alive
dark pink	6 ft	25 hatched	32 alive
	13 ft	red and dry	0 alive
light pink	6 ft	red egg mass	47 alive
	13 ft	2 hatched	0 alive
light pink	9 ft	lost	
	13 ft	covered with sediment	covered with silt

* indicates puncture in cage

RESULTS

After one year, 6 of the 500 *Littorina sitkana* were recovered on the tin can rock. All the animals had grown to roughly 10 mm in length. The rest of the animals had either died or dispersed from the investigated area. One yellow egg mass located on the wave- and sun-sheltered side of a piling stump was found in May 1970. The egg mass, however, dried up before the embryos could hatch.

All the young *Littorina sitkana* caged for 26 hours at the mid-tidal level survived and those retained inside the high tide pools survived (Table 2). However, all the small snails (less than 1.0 mm) caged to the high piling stump were dead. The cages and pool at the high tide level (13 foot) were calculated to be exposed to approximately 11 hours of direct sunshine, those at the mid-tide level (9 foot) for about 6 hours during the duration of the experiment. It would seem that desiccation and not the high temperatures *per se* killed the small snails at the high tide level, since the temperature in the high pool was 7° C higher than the air temperature at the time of measurement (Table 2).

From weather and tide data during the period August 23 to September 1, the 5 foot tide level was estimated to be exposed to a total of 6 hours of direct mid-day sun and the 12 foot level to at least 30 hours. A total of 161 young *Littorina sitkana* hatched at the 5 foot level as opposed to only 2 at the 11 foot level. All the egg masses at the high level had dried out by September 7 (Table 3). This correlation suggests that desiccation was responsible for egg mass mortality at the high tide level but not at the lower.

CONCLUSIONS

The fact that the transplanted *Littorina sitkana* survived at Lilly Point for a year, grew and even reproduced, indicates that no major selective factor was operating during this period of time to prevent adult *L. sitkana* from living at Lilly Point.

Desiccation, acting on egg masses and newly hatched individuals may be a critical factor preventing *Littorina sitkana* from living at Lilly Point and other dry beaches. It is conceivable that a permanent population of *L. sitkana* could be established at Lilly Point if tide pools or damp crevices were added. Egg masses hatched at low tide levels, but the abrasive action of shifting sand and silt, especially during storms, seems to prevent any grazers from living there permanently.

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